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Dynamics of Implementation of SDG 7 Targets in EU Member States 5 Years after the Adoption of the Paris Agreement

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Abstract: The European Union, by adopting the European Green Deal, aims at an extremely ambitious goal to become climate neutral by 2050. This objective implies a massive investment plan to reduce disparities between EU Member States and to support their transformation efforts in order to reshape the Union into a modern, resource-efficient and competitive economy. The objective of this paper is to analyze the dynamics of implementation of SDG 7 targets in EU Member States 5 years after the adoption of the Paris Agreement. Using hierarchical clustering analysis to reveal hidden associative structures, EU countries were grouped in 2015 and 2019 based on Eurostat data in order to identify and analyze key characteristics, but also to evaluate their evolution over time. The results of this research revealed clusters of high-performing countries, as well as countries that require increased attention and support to ease the transition to a greener economy. If in 2015 the cluster of the best performing countries consisted of four EU countries, in 2019, their number increased to eight EU countries, simultaneously with an improvement of the indicators, proving a real concern and involvement regarding the achievement of SDG 7 targets.

Keywords: sustainable development; SDG 7; EU countries; Paris Agreement; COP 21

1. Introduction

Highlighting the sustainable performance of society and the economy in the context of the challenges posed by the 2030 Agenda, the level achieved by each country in terms of the Sustainable Development Goals (SDGs) is now a permanent concern of decision-makers and beyond.

In this sense, we identify the presence of numerous information, statistical analyses and specific indicators that are absolutely necessary for measuring the evolution of each SDG, but which often cannot fully highlight the new challenges or challenges, different from one period to another, from one region to another, an aspect which, unfortunately, complicates decision-making and action processes, especially in countries with lower performance and for which it is necessary to act differently [1,2]. Therefore, even if the successful implementation of the SDG agenda is the only way forward to ensure human well-being, economic prosperity and environmental protection, this is not always possible, as all SDGs must act synergistically, be strengthened and no SDGs, unanimously isolated, must be unable to generate progress.

This is the main reason why scholarly research reflects the need to permanently identify syncopes and challenges for each SDG, at the level of each country and region, but also the analysis of the correlations between them is an absolutely mandatory aspect for Agenda 2030 to be a success for all countries and regions of the world [2,3].

It is also important to note that each SDG has a multidimensional vision of development, and their analyses, individually or in groups, can often generate different results, sometimes synergies (positive results), sometimes compromises (negative results). Regardless of the SDG analyzed or the correlations existing between the SDGs at a certain point in time, we emphasize that the achievement of the 2030 Agenda and implicitly the achievement of the SDGs will largely depend on capitalizing on the synergies identified between the objectives. In addition, the highlighted trade-offs, which are obstacles to achieving the SDGs, need to be overcome and structurally transformed into profound changes in non-functional strategies [3,4]. Consequently, we emphasize that it is imperative to identify the trend that each SDG has at the local and/or regional and global level, as well as the impact that their evolution has on society, the environment and the economy.

Given that 5 years have passed since the adoption of the Paris Agreement and the discussions on the implementation of the European Green Deal occupy an important part of the European agenda, our research aims to assess the dynamics of SDG 7 target implementation in EU countries. Thus, we offer an alternative perspective for analyzing the dynamics of the evolution of EU countries by using cluster analysis and we aim to provide additional information to decision-makers and all stakeholders.

This research is all the more important as a number of researchers or international institutions point out that, although innovative policies and technologies are adapting rapidly to existing realities, the impact of the COVID-19 pandemic significantly changes the forecasts made in early 2020 for the current year. Thus, the objectives of SDG 7 may now be jeopardized, and some targets may be even further away than before [5–7].

Additionally, from the point of view of SDG 7, the concerns are similar and continuous among the directly responsible factors because we can globally identify an accelerated increase in energy demand, both for fossil fuels and for renewable energy [8,9]. This issue needs to be analyzed and debated from multiple points of view as we identify complex issues at the level of resource-providing countries, especially in terms of the impact of unsustainable use of energy sources [9–11].

Based on these considerations, our research contributes to filling the existing gap regarding the level of performance that EU Member States have achieved after 2015 (Paris Agreement) and the current time (2019, the last year for available data), but also to reveal the hidden associative groups of countries, to provide a solid ground for decision-making processes and for substantiating medium- and long-term strategies.

Our research comes as a complement to the study conducted between 1990 and 2017 in the OECD economies, which aimed to identify the type of long-term relationships between the variables of renewable energy consumption and its determinants. The results showed that revenues, human capital, energy productivity, energy prices and eco-innovation are important factors in renewable energy consumption. Therefore, in order to provide viable solutions to environmental problems and to achieve the objectives set out in the Paris Climate Agreement, it is still necessary to design policies and strategies to increase the share of renewable energy in the overall energy mix [12–14].

To highlight the performance of EU Member States, our research uses cluster analysis based on the set of indices identified as defining elements of SDG 7, thus reflecting ongoing processes. Through the research, we also identified the current position of each Member State in relation to the objectives of the 2030 and 2050 Agenda, which generated their grouping in clusters with similar characteristics in terms of the level of performance obtained in access to modern energy services and renewable energy (SDG 7).

On the other hand, the grouping of countries into clusters was also carried out to highlight the degree of responsibility of countries in achieving the specific objectives of SDG

7, the relative position of a country and its inclusion in a group with similar characteristics, depending on the total value of the analyzed indices.

We also consider that the permanent identification of the performance of EU Member States according to SDG 7 is a necessity because SDG 7 is one of the objectives that generates a series of multiple positive effects on society, the environment and the economy, and from this point of view it is necessary that no country/region is left behind.

Key players in the energy sector, both renewable resources and fossil fuels, must continue to commit to improving specific assets and capacities in order to achieve the goal of sustainable development, SDG 7 "Accessible and Clean Energy". Developing countries' capacity for sustainability can also foster overall sustainable development and contribute to the achievement of SDG 7 and the 2030 Agenda [15–17].

Moreover, the COVID-19 pandemic has been and continues to be a wake-up call that the environment and its degradation, global warming and overuse of resources and the existence of polluting industries must be stopped, and the global economy as a whole must become rapidly sustainable, in all respects. The need to accelerate the transition to renewable energy, to an accessible, reliable and sustainable energy system, is supported in all countries of the world, in this case and in the EU, by stepping up clean energy research efforts and stimulating investment in energy infrastructure and clean energy technology [18–20].

Therefore, the ongoing monitoring of SDG 7 is undeniable, as the EU (as well as all regions of the world) focuses on reducing energy consumption, ensuring a sustainable energy supply and improving access to affordable energy [21,22].

We highlight the fact that SDG 7 is supported at the level of all European states through a wide range of strategies and policies to achieve the new climate goals for 2030 and 2050, and the ongoing reformulation of action policies is a constant at the level of The European Commission, as in the current year, 2021, is to make a series of legislative proposals in this regard [23,24].

Consequently, we can emphasize that the achievement of SDG 7 is crucial for human well-being, economic growth and the achievement of global climate change goals. Additionally, in accordance with the Paris Agreement on Climate Change (2015), SDG 7 must be implemented in projects to financially support the economy, transfer technology and strengthen the capacity for sustainable development of society [19,25,26].

Therefore, the constant attention and concern in this direction are also justified by the fact that SDG 7 responds directly to the major requirement to "put the EU on a green path for the new generations". In this regard, we identify targets such as: reduction of at least 55% of net greenhouse gas emissions by 2030 (from 1990 levels), zero net emissions by 2050, reduction of at least 40% of greenhouse gas emissions greenhouse gases (from 1990 levels), with a share of at least 32% for renewable energy and improving energy efficiency by at least 32.5% [27,28].

These priority development targets were another starting point/benchmark in the case of our research because it is obvious that both for 2015 and 2019 (years included in our research), each European state has achieved a series of synergies but also compromises, so that for the coming years, 2030 and 2050, we can identify a sustainable status of society, environment and economy. Moreover, the positive elements highlighted in our research can be capitalized as examples of good practice, and the compromises that must be made directly contribute to the formulation of sustainable transformation strategies.

A relevant point of view for the importance of permanent monitoring of SDG 7 is that of Chirambo (2018), who emphasizes the idea that improved access to energy has the potential to alleviate poverty, promote industrialization, facilitate gender equality and reduce the vulnerability of regions to climate change, and detailed knowledge of each specific detail is a strategic priority [29].

On the other hand, we cannot omit the fact that in many countries, we still identify low electrification rates, and these are undoubtedly the most pressing obstacle to economic growth, more important than access to finance, the presence of bureaucracy or corruption.

Therefore, only policies, strategies and innovations in this field of clean and accessible energy for all can directly contribute to accelerating progress towards universal energy access before 2030 [29,30].

Although there are a number of shortcomings and concerns regarding the achievement of SDG 7 targets at the level of certain regions/countries, we identify an increase in concerns about rural electrification in particular, as well as energy access to agriculture in particular, with a focus on regulating funding frameworks for all energy sectors, issues that can undoubtedly develop success and mitigate negative perceptions of the growth prospects caused by global economic shocks. These initiatives undoubtedly contribute to the favorable growth of inclusion, as the 2030 Agenda seeks, by coordinating and harmonizing investment in this sector, especially in clean energy [30,31].

In the same sense, we mention the fact that the role of economic and non-economic actors that promote sustainability and support the implementation of sustainable energy in their own businesses should not be neglected. This contributes over time to the sustainable development of society in the context of sustainable energy as well as the possibility to explore scenarios and visions for future actions aimed at implementing the SDGs. Therefore, the response (positive or negative) of economic and non-economic agents to the challenges of SDG 7 is one of the reasons why we identify major differences at the level of countries/regions [32–35].

The complexity of how to measure the performance of the SDG and implicitly of SDG 7 at the level of each country should be noted in this context, because they have a double dimension, namely, a technical and a political one. Therefore, this feature sometimes makes it difficult to measure performance, which is why the position of a particular country in a particular hierarchy is often relative and depends almost entirely on the method chosen for research, the indicators selected for ranking and the assumptions taken into account [21,35,36].

We also emphasize that access to sustainable energy at affordable prices is the central objective of SDG 7, which is focused on three priority objectives: ensuring universal access to energy services (7.1), increasing the share of renewable energy sources in the mix, energy efficiency (7.2) and improving energy efficiency (7.3). Additionally, a priority in the implementation of SDG 7 is international cooperation, investment promotion, infrastructure expansion and technology modernization, especially in developing countries [37].

Indeed, clean/sustainable energy is the foundation of human development, through the sustainability of production of any kind and the support of sustainable agriculture and sustainable services, in the context in which energy resources are unevenly distributed globally. These gaps in energy resources and investments in clean/green energy sources are correlated with financial constraints, which has always generated major discrepancies between the developed and least developed countries.

Therefore, achieving the objectives of SDG 7 will have a major impact and will influence the progress of each country in multiple economic, social and environmental dimensions. However, there are connections (some positive, some negative) such as between renewable energy sources (solar, biogas) and human development that could greatly influence the development of rural communities through access to energy, but on the other hand, there is also a certain risk generated by energy prices that could cause some households to give up access to the energy network [38–41].

On the other hand, we cannot omit the fact that the SDG 7 energy efficiency objective is undoubtedly a "win–win" strategy for all economies and countries of the world because each unit of alternative energy created reduces the need for unsustainable energy and the expansion of sources renewable energy and everyone's access to it reduces the risks for each country in terms of long-term development [42–45].

Based on the above considerations, this research aims to assess the dynamics of implementation of SDG 7 targets in the EU, with the help of hierarchical cluster analysis, in order to efficiently segment and identify the common features specific to the groups of best-performing and less-performing countries, but also to reveal associative structure

between countries based on analyzed variables. Our study contributes to the development of knowledge through the analysis made at the countries' level and also provides the knowledge and tools needed to shape a better and responsible future, addressing, at the same time, the existing gap in the current research.

This paper is divided into five sections. Following the introduction, Section 2 presents materials and methods, Section 3 presents the main findings and Section 4 aggregates the conclusions of the research.

2. Materials and Methods

To analyze the transition of EU countries to affordable, reliable and sustainable energy systems, we based our research on latest available data provided by Eurostat for SDG 7—Affordable and clean energy [46] for the years 2015 and 2019.

Using cluster analysis, we aim to identify the grouping patterns of EU countries according to the variables analyzed, aiming to highlight the dynamics of countries between groups and between the two periods considered for analysis. Given that cluster analysis is a hypothesis-generating rather than a hypothesis-testing technique, we aim to present to the research community the results of our study in order to explore new research directions.

Cluster analysis aims to group similar variables into groups so that the degree of association between two variables is as high as possible if they belong to the same group and as low as possible if they belong to different groups. Cluster analysis is mainly used to reveal structures in data without providing detailed explanations or causal interpretations but providing researchers with a distinct way of approaching and interpreting the variables analyzed [47].

Starting from the existing literature, and based on previous research, we consider a series of preliminary hypotheses and will verify whether they are confirmed, in whole or in part, or will be refuted:

(1) The Nordic countries are likely to be grouped in a cluster of countries with high performances in terms of SDG 7;
(2) Small or island countries are potentially in a disadvantageous position in terms of achieving SDG 7 targets, mainly due to the existing environmental conditions;
(3) For countries that have an economy based on depletable resources, the gap will increase over time compared to countries with a high share of RES in the economy in terms of achieving SDG 7 targets.

Selected indicators were processed using basic descriptive statistics. Subsequently, the hierarchical cluster analysis in IBM SPSS Statistics [48] was used to identify clusters for years 2015 and 2019, to underline the key characteristics of the groups of countries, in order to be able to analyze their evolution simultaneously with the redistribution in time between clusters, to better understand the existing relationships [49].

In order to maintain the compatibility between the analyzed data, based on the information provided by Eurostat, the absolute values offered for primary energy consumption and final energy consumption were transformed by means of a dynamic index, based on the year 2000 (similar to greenhouse gas emissions intensity of energy consumption indicator).

Dynamics indices are a measure of the ratio between the size of the economic phenomenon analyzed between two different time periods. It is known that the dynamic indicators refer to homogeneous phenomena described in a single temporal series. Such indices are termed indices of individual dynamics [50–52]:

$$I_{n/1} = \frac{Y_n}{Y_1} \times 100\% \tag{1}$$

where Y_n is the indicator value in a given moment and Y_1 is the indicator value in a comparative period.

2.1. Sample Selection and Variables

The variables were selected for each EU member state, based on Eurostat's latest available data (Table 1).

Table 1. Selected variables for analysis.

Variable	Description	Unit
PRIM	Primary energy consumption—sdg_07_10	Index, year 2000 = 100
FIN	Final energy consumption—sdg_07_11	Index, year 2000 = 100
PROD	Energy productivity—sdg_07_30	Euro per kg of oil equivalent (KGOE)
RES	Share of renewable energy in gross final energy consumption—sdg_07_40	Percent (%)
DEP	Energy import dependency—sdg_07_50	% of imports in total gross available energy
POP	Population unable to keep home adequately warm—sdg_07_60	Percent (%)
GHG	Greenhouse gas emissions intensity of energy consumption—sdg_13_20	Index, year 2000 = 100

Of the variables selected for analysis, "Primary energy consumption" measures the total energy needs of a country excluding all non-energy use of energy carriers, while "Final energy consumption" measures the energy end-use in a country excluding all non-energy use of energy carriers. "Energy productivity" measures the amount of economic output that is produced per unit of gross available energy; "Energy import dependency" shows the share of total energy needs of a country met by imports from other countries and "Greenhouse gas emissions intensity of energy consumption" is calculated as the ratio between energy-related GHG emissions and gross inland consumption of energy.

According to Eurostat, latest available data for greenhouse gas emissions intensity of energy consumption were provided for 2018. To forecast the necessary data for 2019, to maintain the compatibility with the rest of the variables, we used the AAA (Holt-Winters) version of the exponential smoothing (ETS) algorithm with the weights assigned to data variances over time in proportion to the terms of their geometric progression based on the following exponential scale, for the last 10 years (2009–2018): $(1, (1-\alpha), (1-\alpha)^2, (1-\alpha)^3, ..., \infty)$ [53–55].

The descriptive statistics for all the variables used in this research, both for the base year 2015 and target year 2019, are presented in Table 2.

Table 2. Descriptive statistics.

Statistics	PRIM	FIN	PROD	RES	DEP	POP	GHG
			Year 2015				
Mean	99.04	102.83	6.91	20.38	56.73	11.22	88.16
Std. Deviation	8.5129	10.6499	3.2542	11.8860	25.4088	10.4409	9.4833
Minimum	86.03	88.30	2.21	4.99	10.03	0.90	72.40
Maximum	115.27	128.95	16.19	52.95	97.32	39.20	111.80
			Year 2019				
Mean	102.12	108.87	7.49	22.38	59.86	8.19	89.94
Std. Deviation	9.9288	15.2945	3.7593	12.0852	21.9810	7.8567	10.5882
Minimum	87.84	86.17	2.52	7.05	4.83	1.80	52.62
Maximum	125.00	147.37	19.64	56.39	97.17	30.10	103.10

2.2. Model and Method

To check the validity of the assumptions, the first step is to examine available data for normal distribution (Tables 3 and 4).

Table 3. Tests of normality for year 2015.

Variable	Kolmogorov–Smirnov [a]			Shapiro–Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PRIM	0.133	27	0.200 *	0.935	27	0.192
FIN	0.165	27	0.156	0.934	27	0.087
PROD	0.123	27	0.200 *	0.905	27	0.174
RES	0.163	27	0.163	0.931	27	0.095
DEP	0.084	27	0.200 *	0.964	27	0.464
POP	0.190	27	0.013	0.837	27	0.001
GHG	0.101	27	0.200 *	0.972	27	0.654

* This is a lower bound of the true significance. [a] Lilliefors Significance Correction.

Table 4. Tests of normality for year 2019.

Variable	Kolmogorov–Smirnov [a]			Shapiro–Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PRIM	0.107	27	0.200 *	0.957	27	0.316
FIN	0.119	27	0.200 *	0.945	27	0.164
PROD	0.137	27	0.200 *	0.854	27	0.091
RES	0.149	27	0.129	0.917	27	0.133
DEP	0.156	27	0.189	0.959	27	0.346
POP	0.250	27	0.000	0.769	27	0.000
GHG	0.101	27	0.200 *	0.952	27	0.241

* This is a lower bound of the true significance. [a] Lilliefors Significance Correction.

According to the Kolmogorov–Smirnov test, and in concordance with Shapiro–Wilk test results [56,57], of the variables selected for analysis, population unable to keep home adequately warm values indicates a deviation from the normal distribution, which suggests the elimination of this variable from the analysis.

On the other hand, final energy consumption and share of renewable energy in gross final energy consumption normality test results suggest there is a reasonable suspicion that the variable does not follow a normal distribution. Comparing the Kolmogorov–Smirnov with the Shapiro–Wilk test results for these 2 variables, according to the literature and taking into account the sample size and the reduced impact of the type of distribution on the proposed analysis [57,58], we can retain both of them for hierarchical cluster analysis.

The Squared Euclidean Distance Method was used to construct the proximity matrix [59], using the Ward Method to determine the distance between clusters [60]:

$$W = \|w_{ij}\|_{i=\overline{1,n}, j=\overline{1,n}}, \; w_{ij} = \sqrt{\sum_{i=1}^{n} \left(z_{ik} - z_{ij}\right)^2}, \; j = \overline{1,m}, \; k = \overline{1,m} \; j \neq i, \; k \neq i, \; w_{ii} = 0$$

$$\Delta(A, B) = \sum_{i \in A \cup B} \|x_i - m_{A \cup B}\|^2 - \sum_{i \in A} \|x_i - m_A\|^2 - \sum_{i \in B} \|x_i - m_{\mathbf{B}}\|^2 - \frac{n_{A \cap B}}{n_{A \cup B}} \|m_A - m_B\|^2$$

Analyzing the dendrograms of the clusters for the years 2015 (Figure 1) and 2019 (Figure 2) and also taking into consideration the existing literature [61,62], we propose to select a number of four relevant clusters for both 2015 and 2019. The results obtained could provide a broader and more accurate picture of the influencing factors that manifest themselves in the exploiting of renewable energy sources in EU countries.

To check the validity of the clusters, and taking into consideration that we have unequal sample size clusters, we decided to use the Welch Test and the Brown–Forsythe Test (with null hypothesis H_1–H_2: variable means do not differ significantly). The results of the tests are presented in Table 5 (year 2015) and in Table 6 (year 2019).
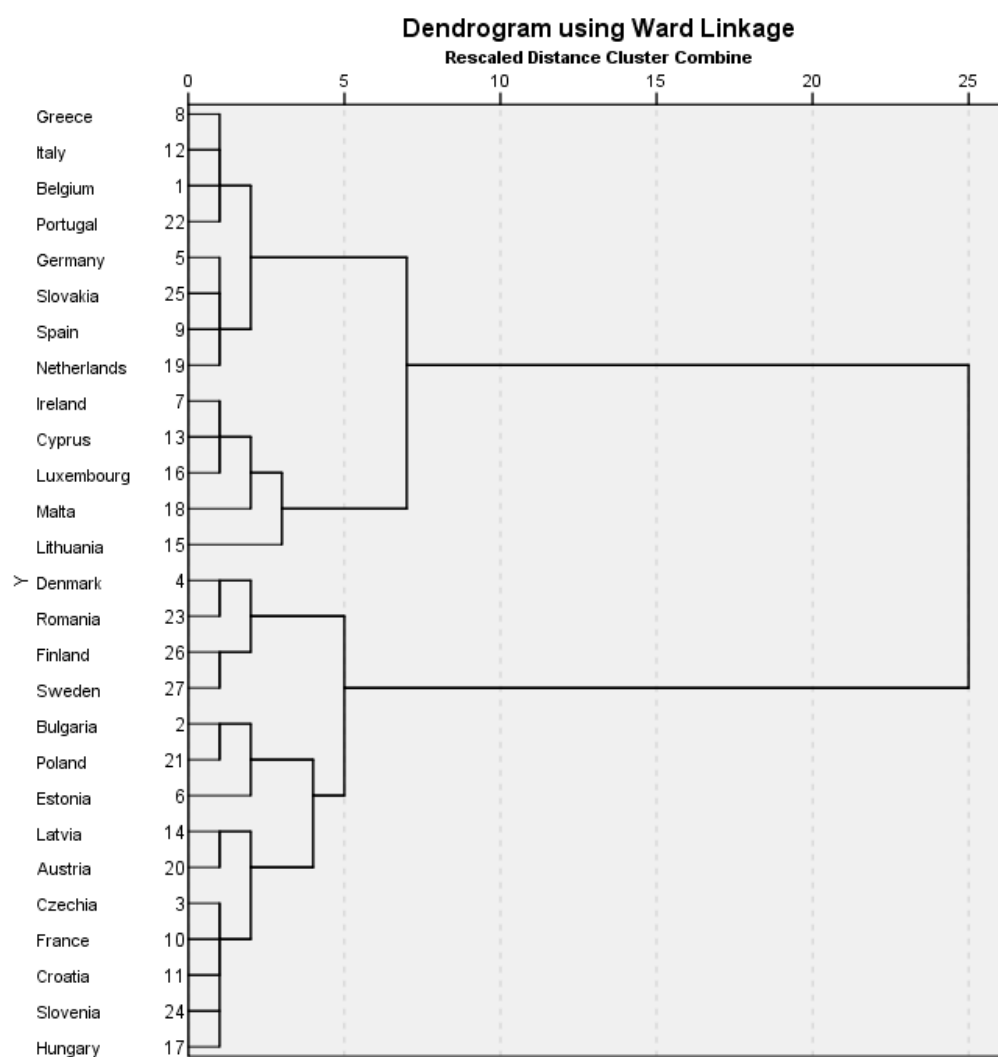
Figure 1. Dendogram of clustering—year 2015.

Table 5. Robust tests of equality of means—year 2015.

		Statistic [a]	df1	df2	Sig.
PRIM	Welch	7.542	3	9.538	0.007
	Brown–Forsythe	6.941	3	13.487	0.005
FIN	Welch	10.323	3	9.964	0.002
	Brown–Forsythe	9.966	3	8.943	0.003
PROD	Welch	2.540	3	8.117	0.039
	Brown–Forsythe	1.353	3	8.737	0.013
RES	Welch	4.851	3	9.082	0.028
	Brown–Forsythe	6.537	3	11.345	0.008
DEP	Welch	25.506	3	9.646	0.000
	Brown–Forsythe	25.095	3	13.306	0.000
GHG	Welch	1.745	3	8.800	0.018
	Brown–Forsythe	1.537	3	11.858	0.036

[a] Asymptotically F distributed. Source: own construction.
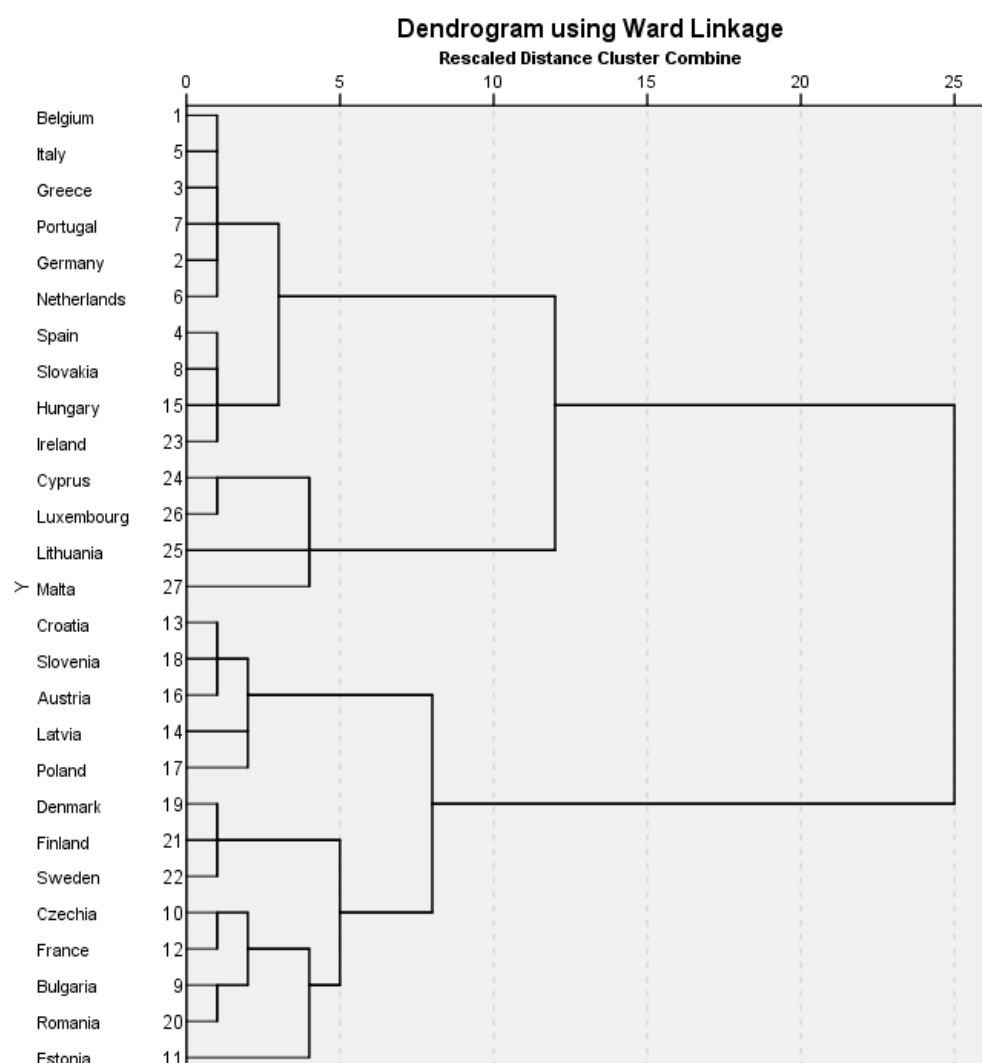
Figure 2. Dendogram of clustering—year 2019.

Table 6. Robust tests of equality of means—year 2019.

		Statistic [a]	df1	df2	Sig.
PRIM	Welch	5.514	3	8.732	0.021
	Brown–Forsythe	5.777	3	9.167	0.017
FIN	Welch	7.517	3	9.099	0.008
	Brown–Forsythe	9.128	3	9.178	0.004
PROD	Welch	0.689	3	10.282	0.038
	Brown–Forsythe	0.709	3	18.744	0.029
RES	Welch	3.481	3	8.737	0.035
	Brown–Forsythe	4.280	3	16.087	0.021
DEP	Welch	24.326	3	7.767	0.000
	Brown–Forsythe	32.858	3	14.384	0.000
GHG	Welch	0.752	3	9.191	0.045
	Brown–Forsythe	0.315	3	4.951	0.031

[a] Asymptotically F distributed.

Subsequently, the results were tested by ANOVA methodology for 2015 and 2019 clusters (Tables 7 and 8).

Table 7. The analysis of variance (ANOVA)—year 2015.

		Sum of Squares	df	Mean Square	F	Sig.
PRIM	Between groups	916.590	3	305.530	7.262	0.001
	Within groups	967.615	23	42.070	-	-
	Total	1884.205	26	-	-	-
FIN	Between groups	1704.708	3	568.236	10.504	0.000
	Within groups	1244.209	23	54.096	-	-
	Total	2948.917	26	-	-	-
PROD	Between groups	56.735	3	18.912	1.990	0.044
	Within groups	218.606	23	9.505	-	-
	Total	275.340	26	-	-	-
RES	Between groups	1810.523	3	603.508	7.452	0.001
	Within groups	1862.672	23	80.986	-	-
	Total	3673.195	26	-	-	-
DEP	Between groups	12,828.341	3	4276.114	24.852	0.000
	Within groups	3957.448	23	172.063	-	-
	Total	16,785.789	26	-	-	-
GHG	Between groups	418.210	3	139.403	1.670	0.021
	Within groups	1920.057	23	83.481	-	-
	Total	2338.267	26	-	-	-

Table 8. The analysis of variance (ANOVA)—year 2019.

		Sum of Squares	df	Mean Square	F	Sig.
PRIM	Between groups	1252.938	3	417.646	7.332	0.001
	Within groups	1310.190	23	56.965	-	-
	Total	2563.128	26	-	-	-
FIN	Between groups	3587.639	3	1195.880	11.027	0.000
	Within groups	2494.323	23	108.449	-	-
	Total	6081.962	26	-	-	-
PROD	Between groups	26.776	3	8.925	0.603	0.032
	Within groups	340.672	23	14.812	-	-
	Total	367.448	26	-	-	-
RES	Between groups	1375.039	3	458.346	4.352	0.014
	Within groups	2422.317	23	105.318	-	-
	Total	3797.356	26	-	-	-
DEP	Between groups	10,404.977	3	3468.326	36.977	0.000
	Within groups	2157.322	23	93.797	-	-
	Total	12,562.299	26	-	-	-
GHG	Between groups	169.518	3	56.506	0.473	0.047
	Within groups	2745.352	23	119.363	-	-
	Total	2914.870	26	-	-	-

3. Results

Starting from the fact that each region/country is constantly monitored in terms of how SDG 7 is reflected in the total sustainable performance, we emphasize that this process is achievable mainly through the following specific indicators: "Primary energy consumption", "Final energy consumption", "Energy productivity", "Share of renewable energy in gross final energy consumption by sector", "Energy import dependence by products", "Greenhouse gas emissions intensity of energy consumption", which indices that our research is based.

Thus, we identify a series of relevant aspects as results of our research from the point of view of the analyzed indicators. Based on the research method described above, according to the existing data for 2015, four representative clusters were identified at the level of the 27 EU member states selected for analysis (Tables 9–12).

Table 9. Cluster A_2015.

No.	Country	PRIM	FIN	PROD	RES	DEP	GHG
1.	Belgium	87.79	95.23	6.47	8.03	83.37	90.10
2.	Germany	93.31	96.59	8.70	14.91	62.13	94.90
3.	Greece	86.03	88.30	7.05	15.69	71.05	85.20
4.	Italy	89.77	93.11	9.88	17.53	77.03	87.60
5.	Netherlands	95.52	93.67	7.51	5.67	48.70	99.60
6.	Portugal	94.35	88.89	7.11	30.52	76.29	86.90
7.	Slovakia	92.68	91.82	4.76	12.88	60.10	84.60
8.	Spain	103.06	100.75	8.22	16.26	72.80	88.60
	Mean values	92.81	93.54	7.46	15.19	68.94	89.69

Table 10. Cluster B_2015.

No.	Country	PRIM	FIN	PROD	RES	DEP	GHG
1.	Austria	115.27	116.03	9.24	33.50	60.37	83.10
2.	Bulgaria	101.69	104.40	2.21	18.26	36.45	111.80
3.	Croatia	102.56	110.00	5.26	28.97	48.79	90.70
4.	Czechia	100.51	96.41	4.08	15.07	32.09	79.40
5.	Estonia	115.22	116.67	3.06	28.53	10.03	92.50
6.	France	102.22	95.87	8.02	14.86	45.93	79.70
7.	Hungary	98.73	107.41	4.38	14.50	53.88	79.00
8.	Latvia	113.16	115.15	4.60	37.54	51.18	86.00
9.	Poland	106.12	113.07	4.36	11.89	29.85	92.20
10.	Slovenia	100.00	102.17	5.66	22.88	49.30	88.40
	Mean values	105.55	107.72	5.09	22.60	41.79	88.28

Table 11. Cluster C_2015.

No.	Country	PRIM	FIN	PROD	RES	DEP	GHG
1.	Denmark	88.48	96.60	14.31	30.87	13.04	72.40
2.	Finland	98.73	99.18	5.73	39.32	47.96	75.80
3.	Romania	88.25	96.48	4.53	24.79	16.69	90.80
4.	Sweden	95.22	90.86	8.54	52.95	30.06	78.60
	Mean values	92.67	95.78	8.28	36.98	26.94	79.40

Table 12. Cluster D_2015.

No.	Country	PRIM	FIN	PROD	RES	DEP	GHG
1.	Cyprus	100.00	100.00	7.01	9.93	97.32	100.50
2.	Ireland	102.19	104.63	16.19	9.04	88.75	87.30
3.	Lithuania	89.23	128.95	4.65	25.75	75.45	105.70
4.	Luxembourg	113.89	114.29	11.07	4.99	95.91	96.30
5.	Malta	100.00	120.00	3.87	5.12	97.30	72.50
	Mean values	101.06	113.57	8.56	10.97	90.95	92.46

The first cluster (A_2015) brings together a number of eight countries (Table 9). The main characteristics of these countries are the lowest average value of final energy consumption (93.54 points) compared to the EU average (102.83 points).

The countries grouped in this cluster are, in general, characterized by lower average values of primary energy production and final energy consumption than in the base period, but also lower than the EU average. The average value of energy productivity (7.46 Euro per KGOE) is higher than the EU average (6.91 Euro per KGOE), and also the average value of energy import dependence (68.94%) is slightly higher than the EU average (56.73%).

At the same time, the average value of the share of renewable energy in gross final energy consumption (15.19%) is about one-third lower than the EU average (20.38%), and the average value of greenhouse gas emissions intensity of energy consumption (89.69 points) is slightly higher than the EU average (88.16 points).

In the B_2015 cluster, at the level of 2015, a number of 10 European countries were grouped (Table 10). The characteristic values for the countries covered in this way are the highest average value of primary energy consumption (105.55 points) and the lowest average value of energy productivity (5.09 EUR per KGOE).

Among the other values that characterize the countries grouped in the B_2015 cluster, we can mention that the average value of final energy consumption (107.72 points) is slightly higher than the EU average (102.83 points), as well as the average value of the share of renewable energy in gross final energy consumption (20.60%) which is slightly higher than the average value registered by EU countries (20.38%). Additionally, the average value of energy import dependency (41.79%) is lower than the EU average (56.73%), while the average value of energy import dependence (41.79%) is substantially lower than the EU average (56.73%).

In terms of the average value of greenhouse gas emissions intensity, the countries grouped in cluster B_2015 register values very close to the EU average (88.28 points compared to, respectively, 88.16 points).

In cluster C-2015, four EU member states were reunited (Table 11). The main features of these four countries are that they record the highest average values for share of renewable energy in gross final energy consumption (36.98%), with almost 50% higher than the EU average (20.38%), as well as the most reduced average values for primary energy consumption (92.67 points compared to the EU average of 99.04 points), energy import dependency (26.94% compared to the EU average of 56.73%) and greenhouse gas emissions intensity (79.40 points compared to the EU average of 88.16 points).

In terms of the average value of final energy consumption (95.78 points), it is at a lower value than the EU average (102.83 points), while the average value of energy productivity (8.28 EUR per KGOE) is higher than the EU average (6.91 EUR for KGOE).

In the D_2015 cluster, the last five EU countries were distributed (Table 12). These are characterized by the highest average values of final energy consumption (113.57 points compared to the EU average of 102.83 points), energy productivity (8.56 EUR per KGOE compared to the EU average of 6.91 EUR per KGOE), energy import dependency (90.95% compared to the EU average of 56.73%) and greenhouse gas emissions intensity (92.46 points compared to the EU average of 88.16 points). Additionally, the countries grouped in this cluster register the lowest average value of the share of renewable energy in gross final energy consumption (10.97%) compared to the average value registered at the level of the European Union in 2015 (20.38%). Additionally, the countries grouped in the D_2015 cluster have an average value of primary energy consumption (101.06 points) slightly higher than the EU average (99.04 points).

Analyzing the data available for the year 2019, using the same method of analysis as for the year 2015, we find the formation of four representative clusters, as well as the existence of different translations of countries between clusters (Tables 13–16).

Table 13. Cluster A_2019.

No.	Country	PRIM	FIN	PROD	RES	DEP	GHG
1.	Belgium	93.70	94.96	6.36	9.92	76.68	82.50
2.	Germany	89.15	97.41	9.70	17.35	67.61	89.58
3.	Greece	89.34	86.17	6.78	19.68	68.86	79.03
4.	Hungary	104.24	114.81	4.85	12.61	69.70	78.10
5.	Ireland	107.30	114.81	19.64	11.98	68.40	82.06
6.	Italy	87.84	92.55	10.28	18.18	77.48	82.25
7.	Netherlands	94.92	95.78	8.26	8.77	64.72	96.26
8.	Portugal	96.09	95.00	7.69	30.62	73.85	85.61
9.	Slovakia	97.56	101.82	5.08	16.89	69.76	81.18
10.	Spain	105.50	107.88	8.85	18.36	74.96	83.05
	Mean values	96.56	100.12	8.75	16.44	71.20	83.96

Table 14. Cluster B_2019.

No.	Country	PRIM	FIN	PROD	RES	DEP	GHG
1.	Austria	117.09	119.41	9.76	33.63	71.73	84.23
2.	Croatia	105.13	115.00	5.75	28.47	56.22	87.61
3.	Latvia	121.05	124.24	4.84	40.98	43.96	82.82
4.	Poland	115.55	128.86	4.79	12.16	46.82	88.99
5.	Slovenia	103.17	106.52	6.26	21.97	52.14	84.72
	Mean values	112.40	118.81	6.28	27.44	54.17	85.67

Table 15. Cluster C_2019.

No.	Country	PRIM	FIN	PROD	RES	DEP	GHG
1.	Bulgaria	102.82	107.69	2.52	21.56	38.10	99.67
2.	Czechia	102.30	100.40	4.55	16.24	40.89	74.53
3.	Denmark	87.96	97.28	16.02	37.20	38.76	68.63
4.	Estonia	102.17	120.83	4.17	31.89	4.83	92.34
5.	Finland	101.58	103.69	5.94	43.08	42.09	68.70
6.	France	98.41	93.99	8.87	17.22	47.60	79.28
7.	Romania	91.69	105.29	5.33	24.29	30.37	83.46
8.	Sweden	99.57	90.29	8.73	56.39	30.24	66.94
	Mean values	98.31	102.43	7.02	30.98	34.11	79.19

Table 16. Cluster D_2019.

No.	Country	PRIM	FIN	PROD	RES	DEP	GHG
1.	Cyprus	108.70	111.76	7.44	13.80	92.81	92.66
2.	Lithuania	96.92	147.37	4.90	25.46	75.22	103.10
3.	Luxembourg	125.00	125.71	11.45	7.05	95.13	89.52
4.	Malta	112.50	140.00	3.48	8.49	97.17	52.62
	Mean values	110.78	131.22	6.82	13.70	90.08	84.48

At the level of 2019, the A_2019 cluster brings together 10 EU countries (Table 13), having as defining features the lowest average level of primary energy consumption (96.56 points) and final energy consumption (100.12 points), as well as the highest average value of energy productivity (8.75 EUR per KGOE).

Regarding the rest of the variables selected for analysis, the countries in the A_2019 cluster have lower values than the EU average for the average share of renewable energy in gross final energy consumption (16.44% compared to the EU average of 22.38%), the average of greenhouse gas emissions intensity (83.96 points compared to the EU average of

89.94 points), and the average value of energy import dependency (71.20%) is higher than the EU average (59.86%).

In the second cluster, B_2019, five EU member states were selected (Table 14), characterized by the highest average value of primary energy consumption (112.40 points) and the highest average value of greenhouse gas emissions intensity (85.67 points), but the lowest average value of energy productivity (6.28 EUR per KGOE).

Additionally, the countries grouped in the B_2019 cluster have higher average values than the European average for final energy consumption (118.81 points compared to the EU average of 108.87 points) and share of renewable energy in gross final energy consumption (27.44% compared to EU average of 22.38%). The average value of energy import dependency (54.17%) is slightly lower than the EU average (59.86%).

Regarding the third cluster, C_2019, it consists of eight EU states (Table 15). The values that characterize this group of states are the lowest average value of energy import dependency (34.11%) and the lowest average value of greenhouse gas emissions intensity (79.19 points), as well as the highest average value for the share of renewable energy in gross final energy consumption (30.98%) among the analyzed countries.

Additionally, the countries in C_2019 register a relatively low average value of primary energy consumption (98.31 points) and for final energy consumption (118.81 points), but also a lower degree of energy productivity (7.02 EUR per KGOE) compared to the EU-27 average (7.49 EUR for KGOE).

In the fourth cluster identified in 2019 (D_2019), four countries were reunited (Table 16), which are characterized by the highest average values of final energy consumption (118.81 points) and the highest average values of energy import dependency (90.08%), together with the lowest average value of the share of renewable energy in gross final energy consumption (13.70%).

Compared to the average values registered at the level of the European Union in 2019, the countries grouped in this cluster register a higher average value for primary energy consumption (110.78 points compared to the EU average of 102.12 points), but also lower average values for energy productivity (6.82 EUR per KGOE compared to the EU average of 7.49 EUR per KGOE) and greenhouse gas emissions intensity (79.19 points compared to the EU average of 89.94 points).

4. Discussion

To facilitate the comparative analysis of the results obtained from the research, results are summarized in Table 17.

Table 17. Mean values for 2015 and 2019 clusters.

No.	Cluster	PRIM	FIN	PROD	RES	DEP	GHG
			Year 2015				
1.	A_2015	92.81	93.54	7.46	15.19	68.94	89.69
2.	B_2015	105.55	107.72	5.09	22.60	41.79	88.28
3.	C_2015	92.67	95.78	8.28	36.98	26.94	79.40
4.	D_2015	101.06	113.57	8.56	10.97	90.95	92.46
	EU average	99.04	102.83	6.91	20.38	56.73	88.16
			Year 2019				
1.	A_2019	96.56	100.12	8.75	16.44	71.20	83.96
2.	B_2019	112.40	118.81	6.28	27.44	54.17	85.67
3.	C_2019	98.31	102.43	7.02	30.98	34.11	79.19
4.	D_2019	110.78	131.22	6.82	13.70	90.08	84.48
	EU average	102.12	108.87	7.49	22.38	59.86	89.94

Based on the results obtained, we can identify, for each year analyzed, which group of countries have proven superior performance and which countries would need to improve their performance in order to keep up with the goals of sustainable development assumed.

Thus, in 2015, following the analysis of research results, we can say that the countries with the best performance in terms of affordable, reliable and sustainable energy systems were grouped in cluster C_2015 (Denmark, Finland, Romania, Sweden), in opposition to the countries grouped in cluster D_2015 (Cyprus, Ireland, Lithuania, Luxembourg, Malta) that did not perform so well. Obviously, in the case of small, possibly insular countries, it is clear that the degree of dependence on energy imports is high, but these countries could benefit from the advantage of geographical positioning to significantly increase the share of RES and energy productivity.

Additionally, for cluster A_2015, it should be mentioned in this context that "Primary energy consumption" is an extremely relevant indicator because it is part of energy plans, but also a result of previous projections of energy consumption at the regional level. As other researchers discuss [63], the demand for energy in the future has a growing trend, and this is because the construction sector, both residential and commercial, is growing, at which point the increased per capita values are added, aspects to be neglected and particularly important from the point of view of the EU targets for 2030 and 2050.

The characteristics values of cluster B_2015 are in line with studies conducted in certain countries, such as Spain (for the period 2010–2015), which indicate that primary energies, such as coal, crude oil and natural gas, will account for an average of 83.6% of total primary energy consumption, raising concerns about the sustainability of supply and the cost of energy [64].

Moreover, the characteristics of cluster B_2015 confirm the theory that, in middle-income countries, both primary and fossil fuel consumption increase CO_2 emissions considerably and lead to the problem of greenhouse gases, wherein there is a direct relationship between urbanization, energy consumption, foreign direct investment (FDI) and carbon dioxide (CO_2) emissions [65–67].

The countries in cluster C_2015 fold over one of the most relevant characteristics of most EU countries, whose final energy consumption is primarily influenced by an increase in energy efficiency in industry, followed by households. The main factors influencing this result are the increase of sustainable economic activity, the increase in the demand for comfort but also social factors, such as the reduction of household size [68].

In the same vein, our results are consistent with the discussions presented in the European Environment Agency Report "Trends and projections in Europe 2019", which argues that the current efforts of Member States are still insufficient to achieve the EU targets set for 2030 [69].

For countries reunited in cluster D_2015, the increase in the "Share of renewable energy in gross final energy consumption by sector" in this group of countries is a wake-up call, as fossil fuels have been used as the main resource for energy production, and their use, unfortunately, has many negative effects, such as global warming and air pollution. On the other hand, the use of fossil fuels negatively influences the strategic dimension of sustainability, namely, the conservation of natural resources.

It is well known that fossil fuel consumption and its relationship with other variables, such as energy dependence and the share of renewable energy in gross final energy consumption, is unfortunately still a problem to be solved in most European countries that are still largely dependent on it, as evidenced by some published research [70,71].

In 2019, the countries grouped in the C_2019 cluster proved again to be the most dedicated to pursuing climate goals and achieving a transition to a sustainable energy system as soon as possible. These countries have a high degree of energy independence (having a degree of energy dependence at almost half the EU average), performing significantly in terms of GHG emissions (on average 20.81% lower than the base period), and managed to reduce their primary energy consumption compared to the reference period. Similar to the previous analysis period, in 2019, the countries with more modest performances were grouped in the D_2019 cluster.

The characteristics of the A_2019 cluster certify that the increase in sectoral energy productivity is the main driver of energy productivity improvements, which is why we

can highlight and support the results of research in the field [72], which emphasizes that countries with similar demographic and economic characteristics have similar levels of energy productivity but also similar rates of improvement.

We note that the situation of countries grouped in cluster B_2019 is slightly deficient in terms of achieving the SDG 7 targets, which is why we emphasize the need for energy management, especially renewable, through constant, quantitative analysis in terms of production, such as and monitoring the performance of each Member State in order to define corrective measures against the targets set by the 2030 Agenda but also by the Paris Agreement of 2015, a need also emphasized by Cucchiella et al. [73].

Regarding the composition of cluster C_2019, it should be noted that they include former communist countries undergoing economic liberalization, and thus prove high rates of improvement of SDG 7 indicators, given the existing development gap compared to the rest of European countries with tradition. As some researchers demonstrate [62], higher levels of per capita income, as well as higher energy prices, are associated with higher energy productivity, while a higher share of industrial production is associated with lower levels of energy productivity, results consistent with our findings.

For Member States grouped in cluster D_2019, we cannot omit, however, the fact that, although economic activity is the greatest driving force to promote carbon emissions, energy intensity is in fact the greatest suppressor, which is why optimizing the industrial structure and intensifying the development of clean energy can effectively prevent the increase of carbon emissions and therefore increase the sustainability of society and the environment, as is also the case in other countries/geographical regions [74,75].

Once the mutations registered by EU countries between clusters are analyzed, we can bring back into discussion the preliminary hypotheses on which we based this research. Thus, about the first hypothesis, that the Nordic countries are likely to be grouped in a cluster of countries with high performances in terms of SDG 7, we can see that indeed the cluster C_2015 includes them, but in 2019, the component of the cluster C_2019 is extended to a number of other countries, but retaining its high performance in terms of SDG 7 targets. In this case, we can consider that the first hypothesis is verified. The results are similar to the findings of Sachs et al. [76] or the International Bank for Reconstruction and Development [5].

Regarding the second preliminary hypothesis, that small or island countries are potentially in a disadvantageous position in terms of achieving SDG 7 targets, we find that the D_2015 cluster brings together a group of countries with limited performance. The same structure is maintained in 2019, except for Ireland, which has made significant progress in achieving SDG 7 targets and has thus been allocated to another cluster. We can say that this hypothesis is also confirmed, but the most important is to highlight Ireland as a model of good practice that should be analyzed and adapted to be implemented in other countries.

Considering the third hypothesis, which assumed that for countries that have an economy based on depletable resources, the gap would increase over time compared to countries with a high share of RES in the economy in terms of achieving SDG 7 targets, the results obtained from this research cannot decisively confirm or refute the assumed hypothesis. However, analyzing the evolution of the variables that characterize clusters B_2015 and B_2019, it is found that the countries grouped in these clusters registered insignificant progress in the analyzed period, or even a decrease in performance at the individual country level, despite the fact that the cluster average suggests some progress over time, albeit limited.

The overall results of our research are also in line with current studies in the field of new, green, sustainable energy sources and respond to the new challenges that the EU, within the "Energy Union" and has taken on: decarbonization (reduction of greenhouse gases and renewable), energy security, energetic efficiency, the internal energy market, or research, innovation and competitiveness [75–78].

Similar results were presented by Popović et al. [79] and Drastichová [80], who, using the same method of analysis, demonstrated the existence of clusters of more advanced countries in terms of involvement in achieving the SDG, and in particular SDG 7. Both papers conclude that the achievements of most developed countries should also be an incentive for those that are at a lower level of development, and the changes in the allocation to clusters also reflect the path of sustainable development in the countries investigated.

Moreover, the concerns regarding the implementation of SDG 7 are not only specific to the countries of the European Union but also to other geographical areas. A number of authors have discussed the progress and obstacles in accelerating the achievement of targets in South Asia [81], India [82], Asia and Latin America [15] and Africa [83]. All these authors emphasize the importance of identifying patterns of good practice and replicating them on a regional or international scale to facilitate the transmission of knowledge to accelerate the achievement of established targets.

5. Conclusions

Given the importance of achieving the sustainable development goals set by the 2030 agenda, our work had as a starting point the analysis of the level of evolution of EU Member States in relation to the targets set by SDG 7, respectively ensuring universal access to modern energy services, improving energy efficiency and increasing the share of renewable energy.

As recent research in the field highlights [2,17,18], the issue of access to modern energy services is a challenge for all EU Member States and beyond, with a number of synergies and trade-offs that each government must take into account, as national/local/regional policies are defining in the transition to the use of renewable energy and consequently the achievement of the 2030 Agenda targets.

Our research thus adds more knowledge in terms of the current state of improved access to energy by highlighting the situation in 2015 in EU Member States and exhaustively in 2019, by identifying cluster-like groups, four in number, for each year analyzed on the basis of indicators relevant for SDG 7.

Although they registered a relatively different evolution in 2019 compared to 2015 (time intervals analyzed), we emphasize that the states grouped in clusters have a number of synergies (strengths), such as the lowest average value of final consumption energy compared to the EU average (cluster A_2019), the highest average value of primary energy consumption and the highest average value of the intensity of greenhouse gas emissions (cluster B_2019), the lowest average value of energy import dependence and the lowest average value of greenhouse gas emission intensity (cluster C_2019), the highest average values of final energy consumption and the highest average values of energy import dependence (cluster D_2019).

The results of our research also highlight the relative changes in positions between Member States' clusters and highlight that there is a permanent dynamic at the level of specific indicators in terms of access to energy, use and supply of green energy, which leads us to the conclusion that changes in the structure of each economy in terms of achieving the targets for 2030 are permanent, constant that favors the change of society and the economy, at least in terms of fossil fuel consumption and pollution reduction.

As we pointed out in our paper, identifying the current state of play of how each European state responds to the European Green Pact, respecting the EU's commitment to global climate action under the Paris Agreement, is a requirement but also a point-of-view reflection to identify the best solutions for Europe to become climate neutral by 2050, with a greenhouse gas-free economy.

Therefore, a relevant conclusion from our study reflects that the analysis of SDG 7-specific indicators is an absolutely necessary step that decision-makers (governments, organizations, companies, etc.) must take to bring the EU closer to the major requirements of the economy being green for the new generations. Thus, a reduction of at least 55% in net greenhouse gas emissions and a reduction of at least 40% in greenhouse gas emissions (from

1990 levels) by increasing the share to at least 32% of renewable energy and improving energy efficiency by 32.5% are certainly targets that can only be achieved by maintaining the current pace of change and intensifying efforts in lagging European countries [24].

Definitely, reducing the vulnerability of EU Member States to climate change can be achieved by identifying the most relevant policies, strategies and innovations (such as investing in green industry by increasing ICT innovation) that could help accelerate progress towards universal access to energy just before 2030. Therefore, access to green energy for industry, agriculture and services of any kind could successfully diversify European economies and reduce negative perceptions of the prospects for increasing energy efficiency, especially through renewable energy.

Not to be neglected in this context is the importance of energy productivity as an objective of SDG 7 and its correlation with the impact of information and communication technology (ICT) on the future of global energy consumption. This is because ICT equipment is consuming more and more energy and can affect the use of energy in almost all sectors, as some researchers argue [12,84].

From this point of view, we also identify a new perspective in terms of the relationship between ICT development and energy consumption because the unbalanced increase in energy productivity in each country can be improved through the development of ICT. Therefore, accelerating the development of ICT, especially in underdeveloped economies, can significantly contribute to sustainable energy consumption, results also confirmed by the existing literature [85,86].

As a corollary, there is no doubt that EU actions, through proposed policies and strategies, through launched initiatives (EU Emissions Trading System, adaptation to climate change, EU external climate finance, LIFE, low-carbon technologies, ozone layer protection, fluorinated greenhouse gases, nature and land use, mainstreaming of climate action, the Covenant of Mayors for Climate and Energy) aims at the permanent improvement of the financing and regulatory frameworks for the energy sectors, thus facilitating the favorable increase of inclusion for the horizon 2030 and later, but much remains to be accomplished.

The results of this empirical study should also be analyzed, taking into account the potential limitations they imply, but which may open new directions for further research. A potential constraint of this research is represented by the availability of the data and the methodological framework. Given that cluster analysis is a hypothesis-generating rather than a hypothesis-testing technique, we can uncover existing structures between selected variables without explaining the reasons for their existence.

The findings of this research could generate future research directions, expanding the set of variables used and trying to identify a generalized model, or target narrow models, to be able to follow the effectiveness of public policies and strategies adopted at the level of the analyzed countries and to assess the medium- and long-term effects on local and regional economies, but also on society as a whole.

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